This model and documentation are provided for non-commercial use only under the CC BY-NC-SA 4.0 license.
No commercial use, profiling, or exploitation of IP logs or trade secrets is permitted.
See full “License and Conditions of Use” notice for details.
In case of conflict or ambiguity, the most restrictive interpretation in favor of non-commercial use, user privacy, and protection of trade secrets shall prevail.
Author: Carlos Daniel Borrego Romero

Master Index - Quantum Hash Descriptor (QHD)

1.0 INTRODUCTION

1.1 Purpose

This Handbook-style index provides a structured navigation guide for the Quantum Hash Descriptor (QHD) documentation set for use by NASA, SpaceX, and other institutional partners.

It is intended to assist technical personnel in locating and applying QHD capabilities for deterministic object identification, kinematic regime description, and trajectory-chain validation.

1.2 Scope

This document is a non-normative master index and user’s guide.

It does not introduce new requirements and does not modify the normative content of the QHD core manuscript or annexes; those documents remain authoritative.

The scope covers:

- Object identity at a given epoch.

- Velocity and kinematic regime identification.

- Trajectory and transfer identity, including coupling to dynamical propagation and ephemerides.

1.3 Applicability

This index is applicable to:

- NASA and SpaceX personnel working with models, simulations, trajectory analysis, and data provenance.

- Contractors and partners implementing or reviewing QHD-based capabilities, to the extent specified in their contracts or technical agreements.

1.4 Relationship to Other Documents

The QHD documentation set consists of the following core elements:

This model and documentation are provided for non-commercial use only under the CC BY-NC-SA 4.0 license.
No commercial use, profiling, or exploitation of IP logs or trade secrets is permitted.
See full "License and Conditions of Use" notice for details.
In case of conflict or ambiguity, the most restrictive interpretation in favor of non-commercial use, user privacy, and protection of trade secrets shall prevail.
Author: Carlos Daniel Borrego Romero

- QHD Core Manuscript: "Quantum Hash Descriptor for Planetary Motion in the Universe" (Phase A).

- Annex A: Earth Base-Case Validation.

- Annex B: Reference Test Vector and Validation Pseudocode for QHD-1.0.

- Annex C: Methodological and Validation Plan for a Second-Generation N-Body Proof of Concept.

- Annex D: Trajectory Identification and A-to-B Transfer Characterization (Phase B).

- Annex E: Velocity Objects and Kinematic-Regime Identification (Phase C).

This Handbook index is intended to be used in conjunction with those documents and with applicable NASA and Center-specific systems engineering and data standards.

2.0 OVERVIEW OF QHD CAPABILITIES

2.1 Functional Capabilities

The combined QHD documentation set supports three principal functional capabilities:

- Deterministic identity of an object at a given epoch (Phase A, Annex A, Annex B).

- Identification and classification of the object's velocity and kinematic regime (Phase C, Annex E).

- Identification and validation of trajectory segments and state chains, including coupling to dynamical propagation (Phase B, Annex D, Annex C).

2.2 Document-to-Capability Map

Table 2-1 provides a mapping between the major QHD capabilities and the primary documents where each capability is defined.

Table 2-1. QHD documentation capability map

Capability

Object identity at epoch

Velocity / kinematic regime

Trajectory and transfer identity

This model and documentation are provided for non-commercial use only under the CC BY-NC-SA 4.0 license.
No commercial use, profiling, or exploitation of IP logs or trade secrets is permitted.
See full "License and Conditions of Use" notice for details.
In case of conflict or ambiguity, the most restrictive interpretation in favor of non-commercial use, user privacy, and protection of trade secrets shall prevail.
Author: Carlos Daniel Borrego Romero

Dynamical coupling and validation

Primary Documents

QHD Core Manuscript; Annex A; Annex B

Annex E (Phase C)

Annex D (Phase B)

Annex C

Supporting Roles

Definition of state descriptor, hash, and base-case validation.

Velocity descriptor, regime classification, extended metadata.

A–B trajectory definition, transfer descriptor, transfer hashing.

N-body / propagator methodology, ephemeris validation, metrics.

3.0 CORE MANUSCRIPT (PHASE A)

3.1 Description

The QHD Core Manuscript defines the theoretical framework for the Quantum Hash Descriptor as a deterministic mapping from physical observables to a continuous descriptor and cryptographic hash.

It establishes the concepts of state representation, entropy and normalized entropy, energy scaling, temporal indexing, causal descriptors, metadata, and canonical serialization.

3.2 Universal Applicability

The core document states that QHD is applicable to planetary systems, stellar systems, exoplanets, galaxies, black holes, nebulae, cosmic filaments, and dark-matter halos, across multiple orders of magnitude in scale.

3.3 Solar System Example

A Solar System snapshot example is provided using the Solar System Barycentric frame and atomic time, with a unified table of bodies that is further elaborated in Annex A.

3.4 Integration with QHF

This model and documentation are provided for non-commercial use only under the CC BY-NC-SA 4.0 license.
No commercial use, profiling, or exploitation of IP logs or trade secrets is permitted.
See full "License and Conditions of Use" notice for details.
In case of conflict or ambiguity, the most restrictive interpretation in favor of non-commercial use, user privacy, and protection of trade secrets shall prevail.
Author: Carlos Daniel Borrego Romero

The manuscript defines canonical tuples, multi-snapshot hash chains, and integration with the broader Quantum Hash Framework for multi-scale physical and informational systems.

3.5 Institutional Applications

The document identifies institutional applications including astronomical provenance, cross-observatory synchronization, simulation reproducibility, catalog integrity, and multi-scale indexing.

4.0 PHASE A VALIDATION (ANNEX A AND ANNEX B)

4.1 Annex A — Earth Base-Case Validation

Annex A documents a complete, deterministic validation case for Earth under the QHD-1.0 protocol.

It specifies the inputs, informational state, entropy, normalized entropy, energy scale, continuous descriptor, canonical JSON, and SHA3-256 digest, and defines validation criteria and outcomes.

4.2 Annex B — Reference Test Vector and Pseudocode

Annex B provides a normative Earth reference test vector and language-agnostic pseudocode for implementation validation.

It defines expected intermediate values, canonical string formats, the canonical JSON object, and the SHA3-256 digest, and describes common failure modes and conformance logic.

4.3 Intended Use

Annex A and Annex B together serve as the baseline for software conformance testing and as a reference for independent replication of the QHD base case.

5.0 PHASE B — TRAJECTORY IDENTIFICATION (ANNEX D)

5.1 Purpose

Phase B extends QHD from single-epoch object identity to identity of a trajectory segment between a defined state A and state B.

It introduces a formal transfer object, trajectory descriptor, and transfer hash, enabling deterministic identification of motion between two states under declared assumptions.

This model and documentation are provided for non-commercial use only under the CC BY-NC-SA 4.0 license.
No commercial use, profiling, or exploitation of IP logs or trade secrets is permitted.
See full "License and Conditions of Use" notice for details.
In case of conflict or ambiguity, the most restrictive interpretation in favor of non-commercial use, user privacy, and protection of trade secrets shall prevail.
Author: Carlos Daniel Borrego Romero

5.2 Phase B Object of Description

The fundamental Phase B object is the directed trajectory segment $\Theta_O(A \rightarrow B)$, constructed from canonical Phase A states at the endpoints, a declared dynamical model, a trajectory summary, and transfer metadata.

5.3 Trajectory Descriptor

Phase B defines a compact trajectory descriptor including elapsed time, net displacement, net velocity change, estimated path length, mean speed, path curvature summary, sampling policy, and uncertainty model.

5.4 Metadata and Validation

Annex D extends the metadata set to include trajectory class, dynamical model, data sources, and uncertainty category, and defines validation logic based on endpoint consistency and transfer consistency under deterministic serialization.

6.0 ANNEX C — DYNAMICAL COUPLING AND VALIDATION

6.1 Purpose

Annex C defines a second-generation N-body proof-of-concept methodology for coupling QHD to a scientifically rigorous trajectory propagation layer.

6.2 System Architecture

The annex specifies a layered architecture comprising reference ephemerides, a dynamical propagation layer, a QHD state-construction layer, canonical serialization, a validation layer, and a provenance layer.

6.3 Dynamical Model Requirements

Annex C lists minimum requirements for serious validation, including N-body gravitational models, consistent reference frames and time scales, appropriate gravitational parameters, integrator quality, and additional perturbation modeling where needed.

6.4 Validation Protocol

The annex prescribes an experimental workflow including benchmark assembly, propagator construction, numerical verification, benchmark comparison versus ephemerides, QHD state capture, and independent repetition.

This model and documentation are provided for non-commercial use only under the CC BY-NC-SA 4.0 license.
No commercial use, profiling, or exploitation of IP logs or trade secrets is permitted.
See full "License and Conditions of Use" notice for details.
In case of conflict or ambiguity, the most restrictive interpretation in favor of non-commercial use, user privacy, and protection of trade secrets shall prevail.
Author: Carlos Daniel Borrego Romero

7.0 PHASE C — VELOCITY AND KINEMATIC-REGIME LAYER (ANNEX E)

7.1 Purpose

Phase C adds a kinematic-regime layer to QHD, enabling deterministic characterization and classification of object velocity and kinematic regime, in conjunction with Phase A and Phase B.

7.2 Velocity Descriptor

Annex E defines a velocity and kinematic descriptor that includes radial velocity, transverse velocity, reconstructed three-dimensional speed, effective acceleration, proper motion, kinematic redshift or Doppler summary, and a normalized regime indicator.

7.3 Regime Classification

The normalized indicator $\eta_v = v_{3D} / v_{ref}$ is used to classify the object within a declared regime structure (for example, standard, high-velocity, extreme, or generalized low, moderate, high, and extreme), with thresholds defined by protocol version and object class.

7.4 Metadata and Chains

Annex E extends the metadata layer to include velocity class, measurement sources, dynamic model, observability class, and uncertainty class, and supports multi-epoch state chains and corresponding chain hashes for moving objects.

8.0 ROLE-BASED USE OF QHD DOCUMENTATION

8.1 Systems Architects and Concept Reviewers

Systems architects should begin with the QHD Core Manuscript and then consult Annex A, Annex C, and Phase B and Phase C annexes to understand integration into larger mission and data architectures.

8.2 Flight Dynamics and Mission Analysis Personnel

Flight dynamics personnel should focus on Annex C for propagator coupling and validation, and on Annex D for trajectory and transfer identity.

8.3 Data, Catalog, and Archival Personnel

This model and documentation are provided for non-commercial use only under the CC BY-NC-SA 4.0 license.
No commercial use, profiling, or exploitation of IP logs or trade secrets is permitted.
See full "License and Conditions of Use" notice for details.
In case of conflict or ambiguity, the most restrictive interpretation in favor of non-commercial use, user privacy, and protection of trade secrets shall prevail.
Author: Carlos Daniel Borrego Romero

Data and archival teams should use the core manuscript and Annex A and Annex B for identity and conformance, and Annex D and Annex E for embedding trajectory and velocity-regime information into catalogs and provenance records.

8.4 Software Implementation and QA Personnel

Implementation and QA teams should treat Annex A and Annex B as the primary conformance references and then extend to Phase B and Phase C modules, using Annex C for integration and system-level tests that involve propagators and ephemerides.

LICENSE AND CONDITIONS OF USE.
The content is licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) license:
https://creativecommons.org/licenses/by-nc-sa/4.0/
By using this content and model, you agree to:
Provide appropriate credit, include a link to the above license, and indicate if changes were made.
Not use the material or any derivative works for commercial purposes.
Distribute any adaptations or derivative works only under the same CC BY-NC-SA 4.0 license.
Not apply legal terms or technological measures that legally restrict others from doing anything the license permits.
Data logging and trade secrets policy.
The design, implementation, and deployment of this model, as well as any derivatives, do not authorize the collection, storage, or exploitation of IP addresses, unique device identifiers, or other technical traceability data for commercial profiling, targeted advertising, or any other economic exploitation.
Any system implementing this model must limit the logging and retention of IP addresses and other identifiable data strictly to what is necessary to:
(a) maintain technical security and service integrity; and
(b) comply with applicable legal obligations (for example, any minimum log retention required by law).
It is prohibited to use this model or its derivatives to:
capture, store, or exploit trade secrets, proprietary know-how, or confidential information of users or third parties for any purpose other than providing the technical service described in this documentation; or train or improve closed, commercial systems using data that contains confidential information of third parties without their prior, explicit, written consent.
Public institutions, space agencies, research organizations, and universities may use this model and documentation for non-commercial research, validation, mission analysis, training, and internal operational support, provided that such use complies with the CC BY-NC-SA 4.0 license and does not convert QHD-based work products into closed, proprietary commercial offerings.

---+EOD+---

This model and documentation are provided for non-commercial use only under the CC BY-NC-SA 4.0 license.
No commercial use, profiling, or exploitation of IP logs or trade secrets is permitted.
See full “License and Conditions of Use” notice for details.
In case of conflict or ambiguity, the most restrictive interpretation in favor of non-commercial use, user privacy, and protection of trade secrets shall prevail.
Author: Carlos Daniel Borrego Romero